Shorter communication

Mindfulness and heart rate variability in individuals with high and low generalized anxiety symptoms

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ABSTRACT

Mindfulness has been incorporated into several treatment approaches for psychopathology. Despite the popularity of this approach, relatively few empirical investigations have examined the relationship between mindfulness and autonomic indicators of emotion regulation, such as heart rate variability (HRV). Generalized anxiety disorder (GAD) has been associated with both low levels of mindfulness and HRV. In this investigation, we examined the relationship between HRV and mindfulness in the context of elevated generalized anxiety (GA) symptoms—analog for GAD—by examining whether GA level moderated this relationship. HRV was collected while participants completed self-report measures of GA and trait mindfulness. GA level interacted with mindfulness in the prediction of HRV; in the high GA, but not low GA group, mindfulness was positively associated with HRV. This suggests that for individuals with high GA, mindfulness may enhance parasympathetic influences on the heart rate. We address the limitations of the current investigation and suggest avenues for future research on mindfulness-related changes in tonic and phasic HRV over time.

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Mindfulness has been conceptualized as the process of bringing attention and awareness to objects within the experience of the present moment with a nonjudgmental and non-evaluative acceptance and openness (e.g., Baer, Smith, & Allen, 2004; Bishop et al., 2004; Brown & Ryan, 2003; Chambers, Gullone, & Allen, 2009; Kabat-Zinn, 1994). Although mindfulness is rooted in Eastern contemplative traditions (Davidson, 2010; Grossman, 2011), it has garnered interest within the behavioral sciences in Western culture. For example, researchers have examined the effects of long-term meditation practice (e.g., Grant, Courtemanche, Duerrden, Duncan, & Rainville, 2010) and the application of mindfulness as a psychosocial intervention (e.g., Baer, 2003). Mindfulness has recently gained popularity as a framework for elucidating psychopathology and physical health (see reviews by Baer, 2003; Grossman, Niemann, Schmidt, & Walach, 2004; Hofmann, Sawyer, Witt, & Oh, 2010). Mindfulness has also been incorporated into several treatment approaches for a variety of mental disorders, including mood (e.g., Segal, Williams, & Teasdale, 2002), anxiety (e.g., Roermer, Orsillo, & Salters-Pedneault, 2008), substance-related (e.g., Witkiewitz, Marlatt, & Walker, 2005), and personality (e.g., Linehan, 1993) disorders. Mindfulness-based approaches have demonstrated efficacy in ameliorating symptoms of these disorders (e.g., Hofmann et al., 2010).

Despite this increasing interest, the processes by which mindfulness may confer its benefits in alleviating symptoms and improving functioning requires further elucidation. Emotional regulation is one potential framework for understanding mechanisms of mindfulness; conceptualized as the processes by which individuals modulate the experience, expression, and response to emotions (Gross, 1998), it has been associated with the development and maintenance of psychopathology (see Aldao, Nolen-Hoeksema, & Schweizer, 2010; Kring & Sloan, 2010; Mennin & Fresco, 2010). Indeed, mindfulness has been increasingly examined in terms of its relationship to emotional processes (Davidson, 2010) and has been associated with indicators of improved ability to regulate emotions (e.g., Baer, Smith, Hopkins, Krietsmeyer, & Toney, 2006; Coffey & Hartman, 2008; Jimenez, Niles, & Park, 2010; Lykins & Baer, 2009). Mindfulness practice might contribute to the development of effective emotion regulation (see Chambers et al., 2009). Mindfulness may facilitate effective...
emotion regulation through improved ability to flexibly process emotional experiences through “being”—when attention is allocated to the experience and one's attributions of the experience—rather than simply “doing”—when attention is allocated simply to the procedural aspects of the experience (Williams, 2010). Mindfulness practice may also facilitate the capacity to perceive thoughts and emotions while understanding that they do not necessarily have to be acted upon, allowing for the appropriate allocation of energy and appraisal (e.g., Chambers et al., 2009). Cultivating mindfulness may also influence the activity of the neural structures associated with effective emotion regulation. For example, the implementation of a mindfulness-based intervention for social anxiety disorder resulted in reduced amygdala activity during a breath-focused attention task (Goldin & Gross, 2010) and dispositional mindfulness has been related to activation of prefrontal cortex regions involved in attenuation of amygdala response during an affect labeling task (Creswell, Way, Eisenberger, & Lieberman, 2007).

Just as mindfulness has informed several approaches for the treatment of psychopathology (e.g., Hofmann et al., 2010), emotion regulation has also been incorporated into psychosocial interventions, such as Dialectical Behavior Therapy (Linehan, 1993) and Emotion Regulation Therapy (Mennin & Fresco, 2010). These treatment approaches aim to increase utilization of adaptive emotion regulation strategies and reduce reliance on maladaptive strategies. Further, the inclusion of mindfulness practice in these approaches may play a role in facilitating changes in one's relationship to emotion experiences, potentially resulting in improved flexibility in emotion regulation.

Generalized anxiety disorder (GAD), which is characterized by excessive and uncontrollable worries for more days than not (APA, 2000), has been associated with both difficulties in emotion regulation (Behar, DiMarco, Heckler, Mohlman, & Staples, 2009; Mennin, Haloway, Fresco, Moore, & Heimberg, 2007; Newman & Llera, 2011; Thayer, Friedman, & Borkovec, 1996) and low levels of mindfulness (Roemer et al., 2009). Germane to this investigation, Roemer et al. (2009) have shown that there is a strong relationship between mindfulness and emotion regulation within the context of GAD and that both mindfulness and emotion regulation contributed independently to the variance in the severity of symptoms.

Given that emotions are multi-faceted processes (e.g., Bradley & Lang, 2000), their regulation can be assessed through multiple channels including self-report, behavioral observation, and physiological response (e.g., Aldao, 2013). One autonomic indicator of flexible emotion regulation is heart rate variability (HRV), which represents the degree of parasympathetic and sympathetic influence on heart rate, with higher levels indicating increased parasympathetic and reduced sympathetic influence (e.g., Appelhans & Luecken, 2006; Porges, 2007). Of particular interest, specific metrics of HRV putatively reflect parasympathetic activity independently (e.g., mean of the absolute value of the difference between successive interbeat intervals; MSD; Allen, Chambers, & Towers, 2007). MSD indicates vagally mediated HRV (see Lyonfield, Borkovec, & Thayer, 1995).

In his Polyvagal Theory, Porges (2007) describes the relationship between emotion regulation and HRV, such that the neural pathways originating in the cranial nerves innervate and regulate the facial muscles and the myelinated vagus regulates the heart and bronchi. The myelinated vagus influences the efferents of the sinoatrial node to promote or impede the degree of engagement in social and emotional behaviors, thus playing a major role in the experience, expression, and response to emotion (Porges, 2007). Thayer, Åhs, Fredrikson, Sollers, and Wager (2012) note that HRV may also be an effective index of activation of the medial prefrontal cortex regions (mPFC), which guide amygdala and subsequent brainstem nuclei that influence regulation of the heart, reflecting emotion regulation processes. Individuals with relatively low HRV tend to have increased difficulties in emotion regulation in contexts requiring it and the opposite might be the case for those with elevated HRV (Porges, 2007). Additionally, low HRV might be a risk factor for psychopathology (Thayer & Lane, 2009). Of interest to this investigation, individuals with GAD and non-clinical high trait worryers have been shown to have lower levels of HRV than to low-worry controls (Brosschot, VanDijk, & Thayer, 2007; Thayer et al., 1996). Also, Delgado et al. (2010) have demonstrated that in a non-clinical high worry sample, mindfulness training was associated with improved emotion regulatory abilities and respiration, a related peripheral indicator of emotion regulation. However, little work has been done to examine HRV as it relates to mindfulness, particularly in the context of elevated anxiety symptoms.

The current study

In this investigation, we examined the relationship between trait mindfulness and HRV within the context of elevated generalized anxiety symptoms (GA), as an analog for GAD. Given its association with mindfulness and HRV, we evaluated whether GA level would moderate the relationship between trait mindfulness and HRV collected during questionnaire administration. We predicted that trait mindfulness would be associated with a higher level of HRV across and within both high and low GA groups. In addition, we predicted lower levels of mindfulness and HRV would be found in individuals with high GA. Finally, we examined whether mindfulness would interact with GA level in the prediction of HRV.

Method

Participants

The sample consisted of undergraduates attending a private university in a Northeastern region of the United States. We recruited participants via flyers posted throughout the campus and neighboring areas. The flyers advertised a study for which participants could earn up to $40 for three hours of participation (this data collection included investigations not related to the current hypotheses). We recruited some participants through over-sampling for high worry through using flyers that also included the question, “Are you a worrier?” at the top of the flyer. As the study protocol called for psychophysiological assessment, prequalification requirements included the absence of a history of a cardiac condition, diabetes, or high blood pressure to rule out physical factors that could account for results. In addition, study participants needed to be currently enrolled in the undergraduate program and be between the ages of 18 and 23. A total of 67 undergraduate students (50.7% female) participated in the current study and the additional studies included in the protocol. The mean age was 20.17 years (SD = 1.35, range 18-23). The sample identified themselves as Caucasian (56.7%), African American (14.9%), Asian (11.9%), Hispanic (10.4%), and other (4.5%). One participant declined to identify a race or ethnicity (1.5%).

Self-report measures

Generalized anxiety disorder questionnaire – IV

(GADQ-IV, Newman et al., 2002). The GADQ-IV is a self-report measure that assesses GAD symptoms. It consists of five dichotomous items that assess for the presence of GAD symptoms as defined by DSM-IV, one open-ended item asking participants to list up to six most frequent worry domains that are experienced as excessive and uncontrollable; one item asking about the presence...
of six different physical symptoms often associated with worry; and two items on a 9-point Likert-type scale that assess the distress caused and interference experienced due to worry and associated physical symptoms. Newman et al. (2002) identified a 5.7 cutoff score to differentiate those who meet clinical levels of GAD. We utilized this cutoff in the present investigation to create two groups: participants high (n = 22) and low (n = 45) in GA, as an analog for the presence and absence of GAD respectively. These groups did not differ significantly in age, t(64) = −1.43, ns; gender, χ²(1) = .91, ns; or reported race and ethnicity, χ²(4) = 3.32, ns.

**Cardiac measures**

We acquired cardiac data while participants completed questionnaires. We utilized the Polar RS400 Heart Rate Monitor, which recorded interbeat interval (IBI) data. We imported the IBI series for analysis into Polar Protrainer 5 utilizing the Polar IrDA USB 2.0 adapter. We then imported the IBI series into an electronic spreadsheet for semi-automated identification and mean replacement of outliers (defined here as a high-IBI value of “1200 and above” or low-IBI value of “200 and below”). Next, this clean IBI series was imported into specialized software, CmetX (Allen et al., 2007), for calculation of an HRV metric, specifically the mean of the absolute value of the difference between successive IBIs (MSD; Allen et al., 2007). As indicated earlier, MSD is a time domain metric of HRV that indexes the degree of parasympathetic influence on heart rate (Allen et al., 2007; Lyonfields et al., 1995). As heart rate data were collected during the completion of questionnaires, data collection time varied. In order to calculate the mean for a near-standard length for the collected data, we examined levels of cardiac responding during the first four 1400 IBI segments and the mean MSD of these four segments was utilized in this analysis.

**Results**

Participants in the high GA group scored significantly lower on MAAS than did participants in the low GA group, t(65) = 2.19, p < .05 (see Table 1). Participants in the high and low GA groups had similar levels of MSD, t(65) = −.37, ns.

Using regression analysis, MAAS predicted differences in MSD, β = .27, t(66) = 2.23, p < .05. We examined GA level as moderator in the relationship between MAAS and MSD. Using simple slopes analyses (Aiken & West, 1991), we found that GA level interacted with MAAS in predicting MSD, β = .43, t(63) = 3.02, p < .01 (see Fig. 1). In the high GA group, MAAS was significantly positively associated with MSD, β = .53, t(20) = 2.82, p < .05. In the low GA group, MAAS was not significantly associated with MSD, β = .14, t(43) = .94, ns.

**Discussion**

Mindfulness has been related to several indicators of flexible emotion regulation (e.g., Arch & Craske, 2006; Feldman, Kumar, Greeson, & Laurenceau, 2007; Goldin & Gross, 2010; Roemer et al., 2009). However, there is a scarcity of research examining the relationship between mindfulness and autonomic indicators of flexible emotion regulation such as HRV. In this investigation, we examined the relationship between trait mindfulness and HRV during questionnaire administration in participants with high and low levels of GA symptoms. We found that GA level moderated the relationship of mindfulness and HRV, such that only in the high GA group was mindfulness significantly associated with HRV. This study provides preliminary support for including the development of mindfulness in treatments for GAD. Indeed, a number of promising therapies have incorporated mindfulness practice into the treatment of this condition (e.g., Roemer et al., 2008; see Hofmann et al., 2010 for a review of the efficacy of these approaches).

The lower level of trait mindfulness found in the high GA group is consistent with past research (e.g., Roemer et al., 2009). Further, participants in the low GA group did not demonstrate the same pattern as those in the high GA group; in the low GA group, trait mindfulness and HRV were not significantly related, whereas the high GA group appeared to benefit from the utilization of mindfulness during the completion of questionnaires. A possible explanation is the compensatory hypothesis (Aldao & Nolen-Hoeksema, 2012), which posits that the utilization of adaptive strategies is most predictive of improvement in psychopathology outcomes for individuals who utilize higher levels of maladaptive strategies. Mindfulness can be considered an adaptive strategy that is predictive of enhanced parasympathetic influence within the context of individuals who tend to utilize higher levels of maladaptive strategies. Further, the low GA group may not engage as frequently in maladaptive strategies, thus reducing the strength of the relationship between the adaptive strategy of mindfulness and its positive concomitants.

Higher HRV suggests that a person’s heart rate fluctuates more flexibly (see Thayer et al., 2012). However, in determining whether

<table>
<thead>
<tr>
<th>n</th>
<th>MAAS (SD)</th>
<th>Range</th>
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<tbody>
<tr>
<td>Overall</td>
<td>67</td>
<td>3.63 (0.59)</td>
</tr>
<tr>
<td>MAAS</td>
<td>45</td>
<td>3.43 (2.34)</td>
</tr>
<tr>
<td>Low GA</td>
<td>22</td>
<td>3.73 (6.00)</td>
</tr>
<tr>
<td>MSD</td>
<td>33.65 (16.27)</td>
<td>4.58–82.41</td>
</tr>
<tr>
<td>High GA</td>
<td>22</td>
<td>3.41 (5.00)</td>
</tr>
<tr>
<td>MSD</td>
<td>35.89 (34.10)</td>
<td>4.09–170.38</td>
</tr>
</tbody>
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a given value of HRV represents adaptive versus maladaptive fluctuations in the heart rate, the context in which it is assessed must be taken into account. In the current investigation, the context of assessment was during questionnaire administration. Further, the highest values of MSD were found in participants who reported elevated GA and a mindful disposition. This higher MSD may reflect higher emotionality in individuals with elevated GA symptoms. This higher emotionality is attenuated by the worry often used by individuals in this group. Yet, when such individuals have high levels of mindfulness, this might, in turn, counteract the suppressing effects of worry on emotional experience, allowing the heightened emotionality characteristic of this disorder to manifest. Relatedly, individuals in the low GA group may have displayed lower HRV regardless of their mindfulness because they might have needed a more emotionally evocative context than the administration of questionnaires to elicit the protective qualities that trait mindfulness may provide. To fully test this assumption, it would be interesting for future investigations to examine and manipulate state levels of worry, mindfulness, and HRV (e.g., Delgado et al., 2010).

The current study had several limitations and the results must be considered within these limitations. First, the utilization of a student population and a self-report instrument of GA allowed only for the examination of analog GAD. The restricted sample utilized may present differently than a clinical sample in terms of trait mindfulness and HRV based on factors other than GA. Thus, future studies should examine this relationship in a clinical sample to extend these findings to GAD. Another important methodological limitation of this study was the use of a self-report measure of mindfulness. Although self-report may contribute to the improved operationalization of mindfulness (Bishop et al., 2004) and thus improved examinations of potential mechanisms of change in mindfulness-based interventions, self-reports are prone to measurement error. The current study provides preliminary support for the inclusion of HRV as part of the multimodal assessment of pathology for which dysregulation is a component. Furthermore, HRV has the potential to be utilized as an index of improvement in regulatory functioning over the course of a mindfulness-based therapeutic intervention. Indeed, a few studies have begun to include the assessment of autonomic physiological variables in their delineation of treatment effectiveness (e.g., Delgado et al., 2010). If additional research demonstrates a strong relationship between mindfulness and HRV, then changes in HRV can be utilized to assess the potential effectiveness of the mindfulness component of the intervention.

Conclusion

This investigation points to the potential utility of including the development of mindfulness in interventions that target emotion regulation deficits, such as those frequently observed in individuals with GAD. There was a stronger relationship between mindfulness and HRV in the high GA group than in the low GA group. This provides some support for the compensatory hypothesis (Aldao & Nolen-Hoeksema, 2012), in that higher levels of adaptive strategies are utilized in the presence of higher levels of maladaptive strategies. This investigation provides preliminary support for the protective role of mindfulness in individuals suffering from psychopathology. Future research will be necessary to further delineate mechanisms by which mindfulness impacts physiology and emotion regulation both concurrently and prospectively.

References


